



USING LiDAR TO LINK FOREST CANOPY STRUCTURE WITH BAT ACTIVITY & INSECT OCCURRENCE: PRELIMINARY FINDINGS

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Remote Sensing & Wildlife



- Large-scale patterns¹
 - Feasibility
 - Necessity

¹ Vierling et al. 2008. *Frontiers in Ecology & the Environment* 6: 90-98.
Hudak et al. 2009. *Remote Sensing* 1: 934-951.

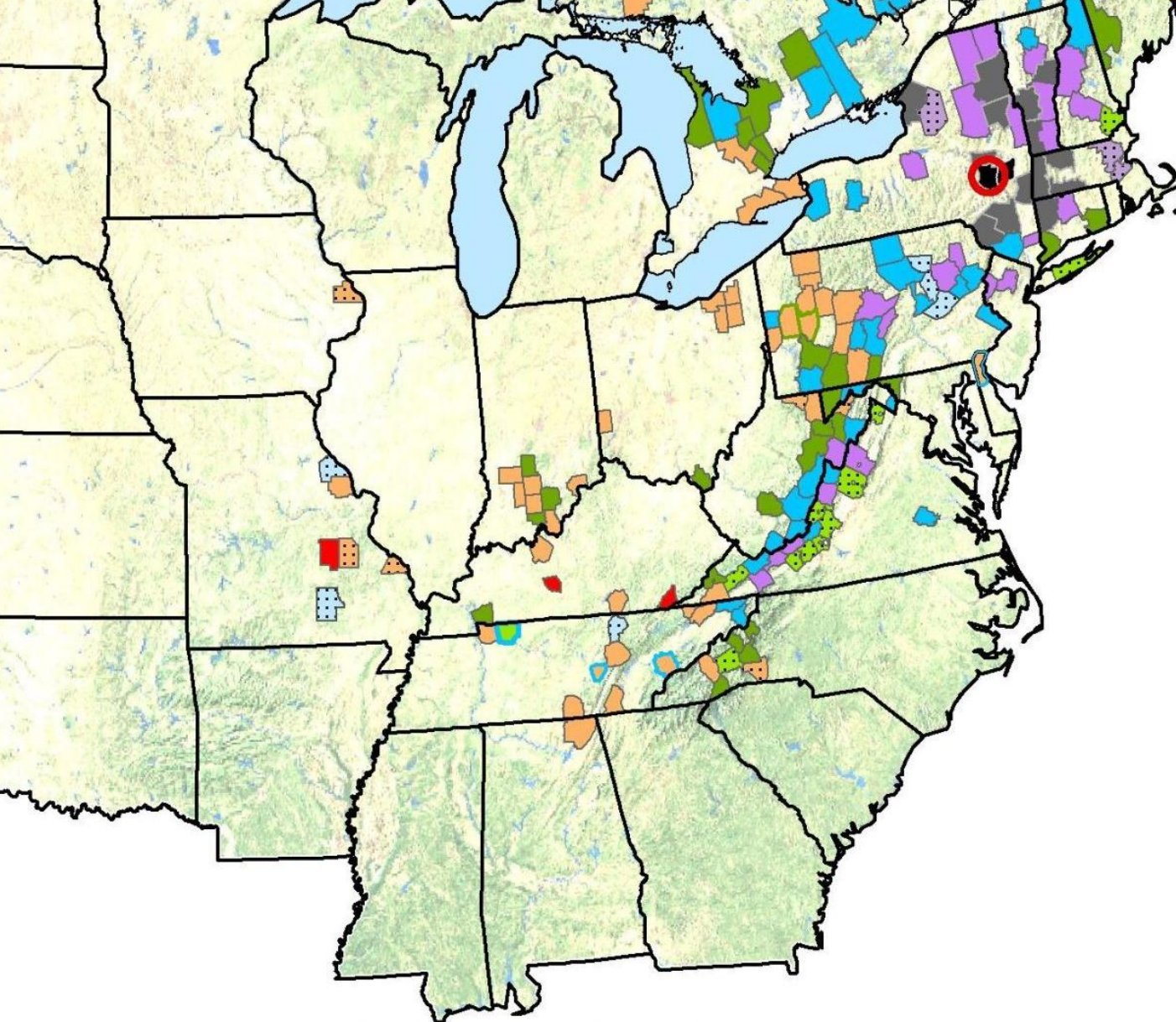
Bats at Mammoth Cave

- Variable foraging & habitat use across species¹
 - Prey availability & forest canopy structure
- White-nose syndrome (WNS)
 - Now at Mammoth Cave; changing predator-prey dynamics?



¹Swartz et al. 2003. Pp. 257-300 in: Bat Ecology.

Lacki et al. 2007. Pp. 83-128 in: Bats in Forests: Conservation and Management




01/25/2013

Bat

White Nose Syndrome (WNS)
Occurrence by County/District*

(or portions thereof)

 Feb. 2006: 1st detected
in Schoharie Co., NY

 Mortality-Winter 2006-07


Fall/Winter/Spring

2007-2008:  Confirmed


2008-2009:  Confirmed

 Suspect


2009-2010:  Confirmed

 Suspect


2010-2011:  Confirmed

 Suspect

2011-2012:  Confirmed

 Suspect

2012-2013:  Confirmed

 Suspect

*Confirmed
Confirmed by
State / Province.
(outline color=suspect year)

*Suspect
WNS symptoms reported
but not confirmed by
State / Province.

100 50 0 100 200 300 400 500 600 700 800 900 1,000 Miles

0 100 200 400 600 800 1,000 1,200 1,400 1,600 1,800 Kilometers


Map by: Cal Butchkoski, PA Game Commission

01/25/2013

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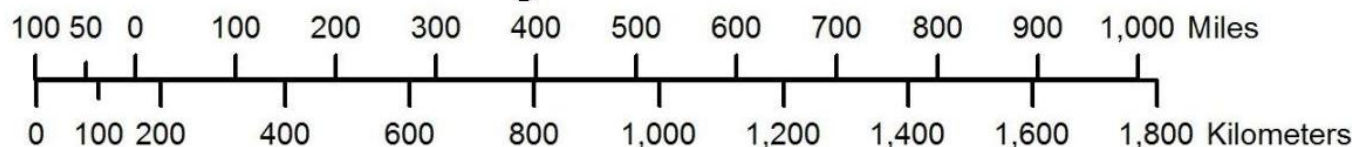
*Confirmed

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(outline color=suspect year)

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Map by: Cal Butchkoski, PA Game Commission

Methods

Mammoth Cave National Park

Burn Areas

- 2010

- 2009

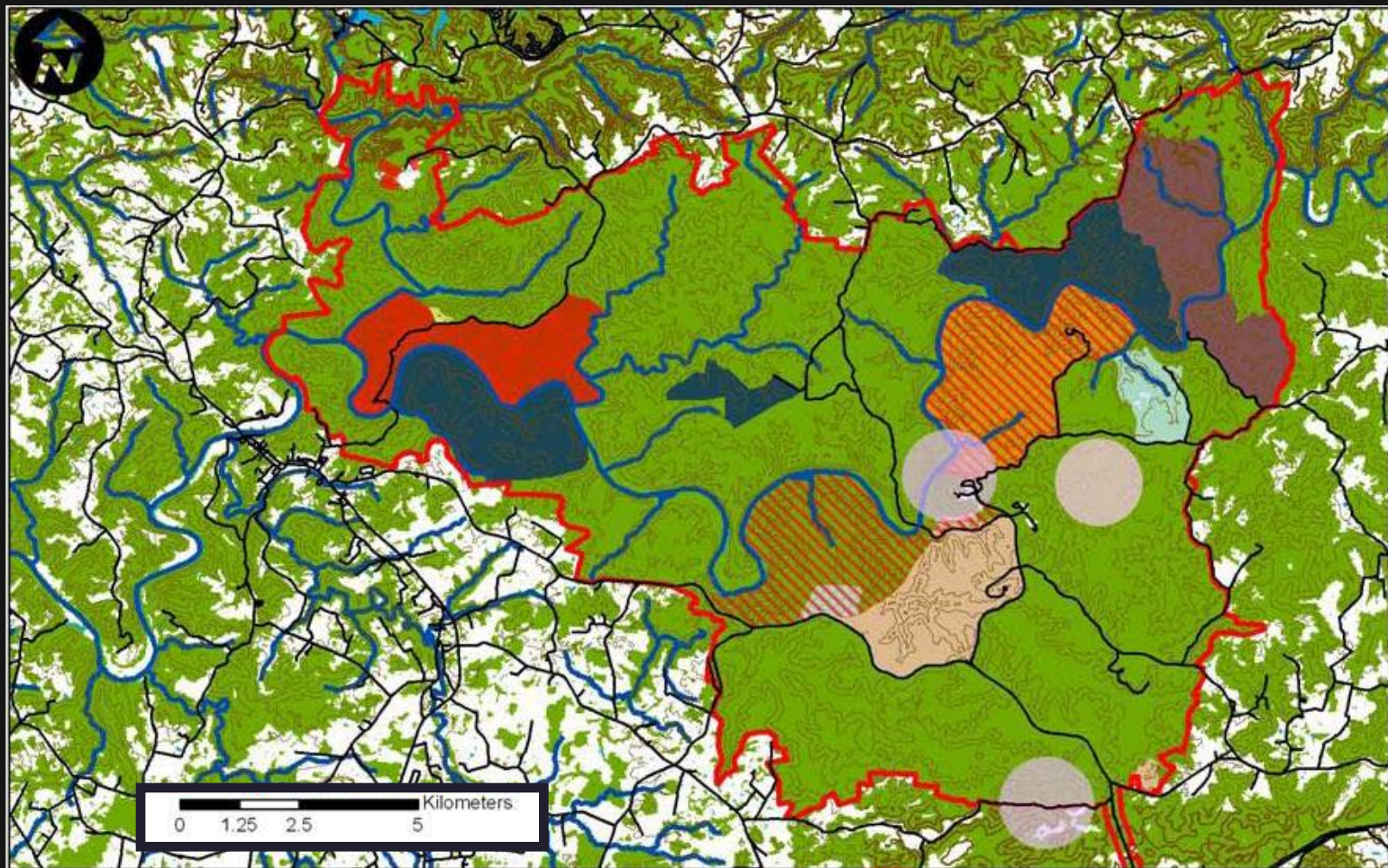
- 2008

- 2007

- 2005

- 2004

Core
Hibernacula



Methods

Mammoth Cave National Park

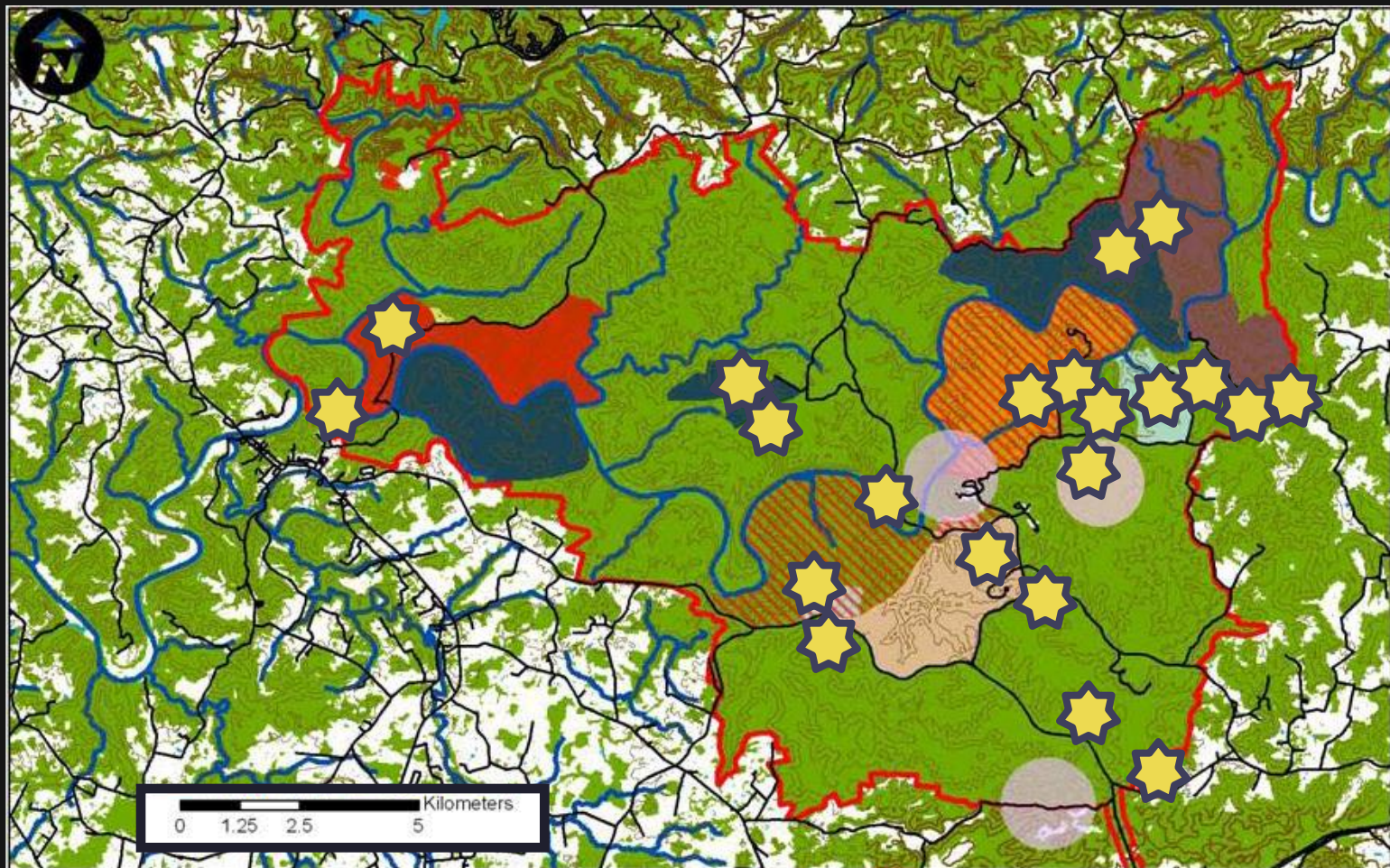


Survey Transect,
2010-2011

Burn Areas



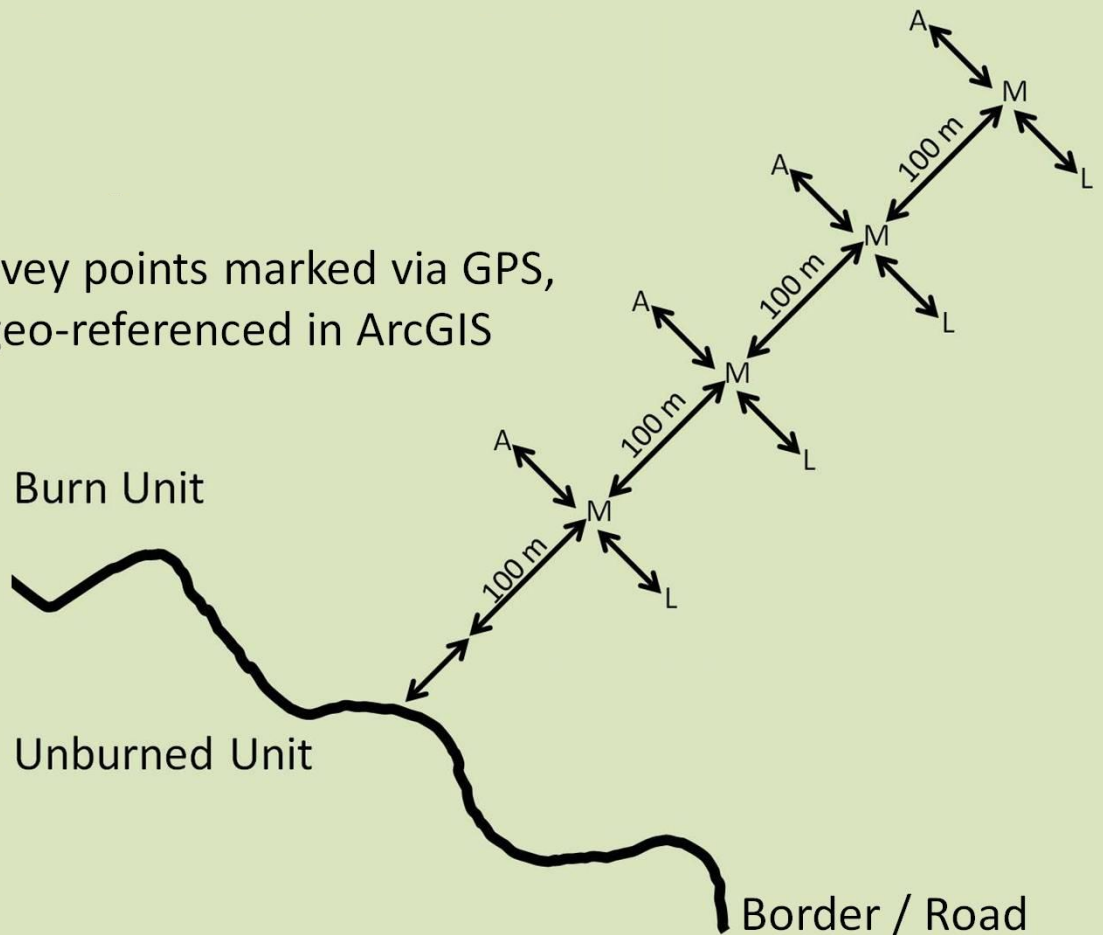
Core
Hibernacula



Methods

Mammoth Cave National Park

All survey points marked via GPS,
then geo-referenced in ArcGIS

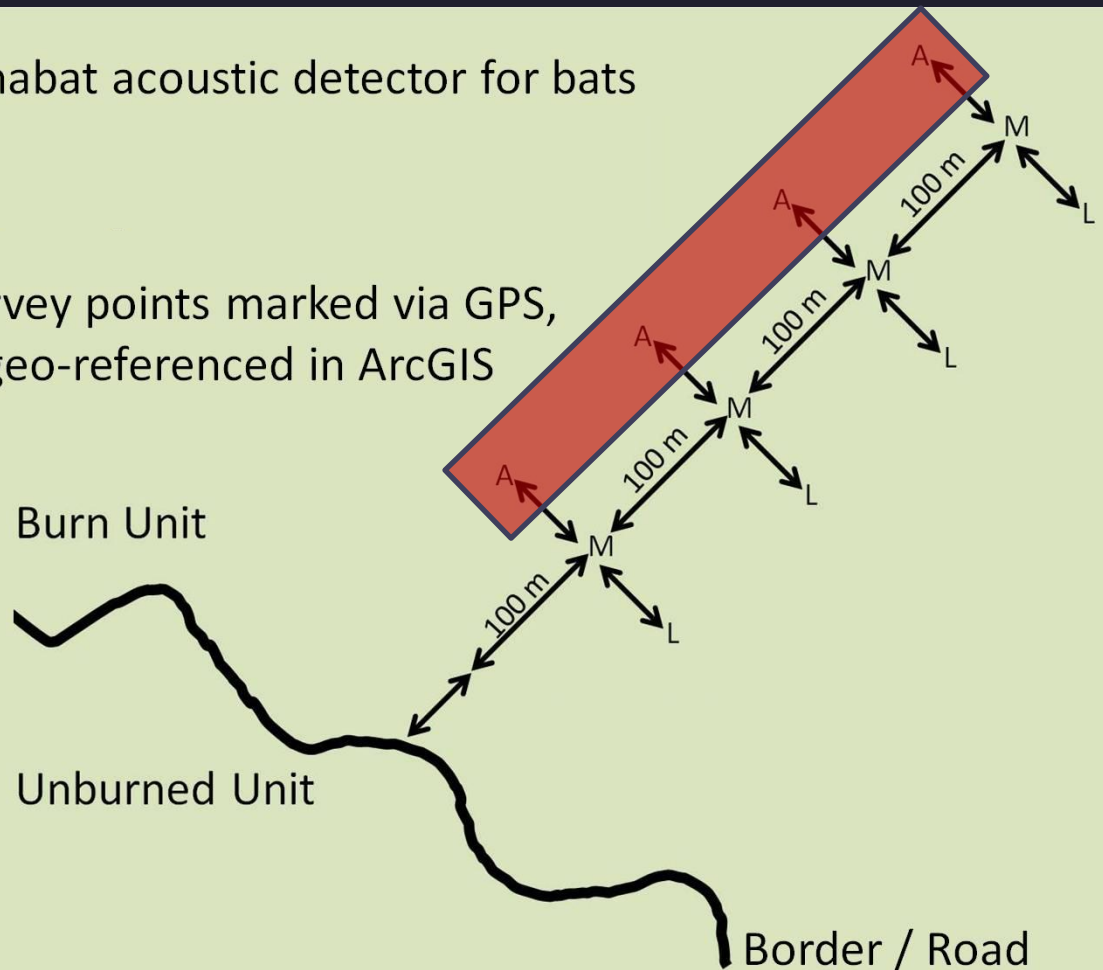


Methods

Mammoth Cave National Park

A = Anabat acoustic detector for bats

All survey points marked via GPS,
then geo-referenced in ArcGIS



Methods

Bat Activity



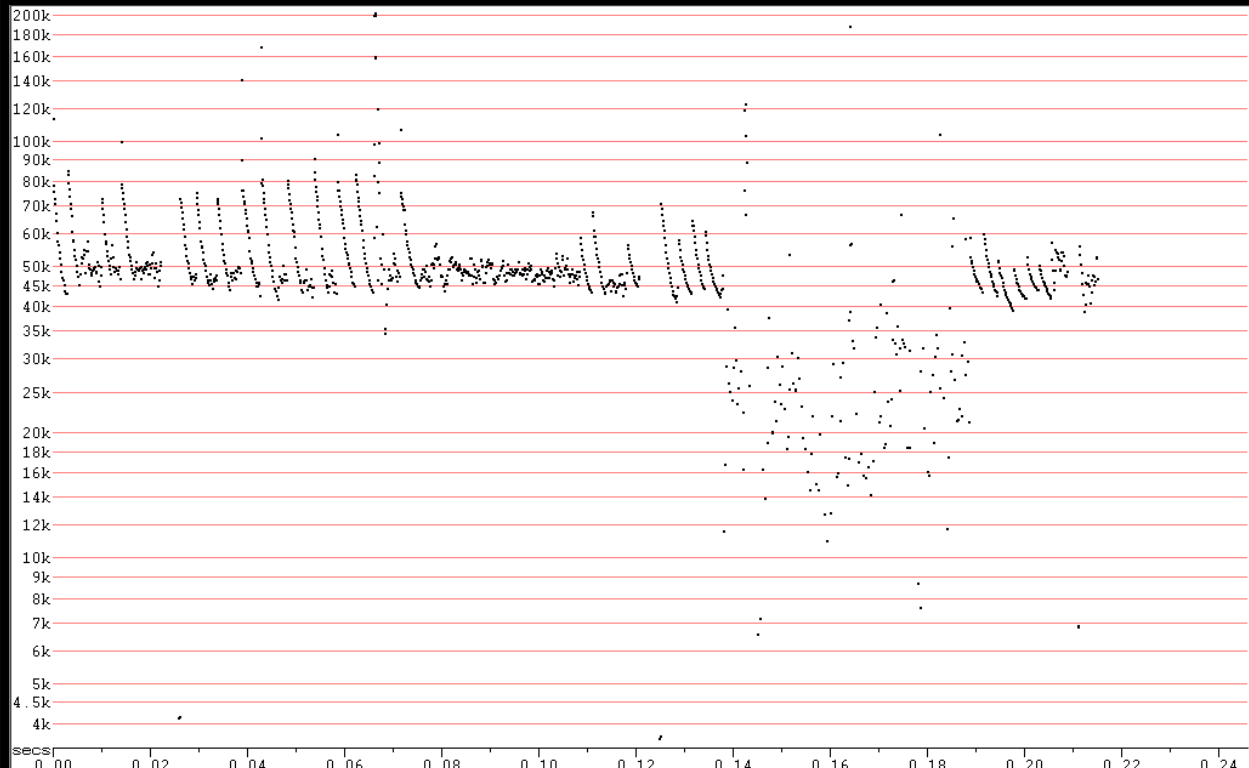
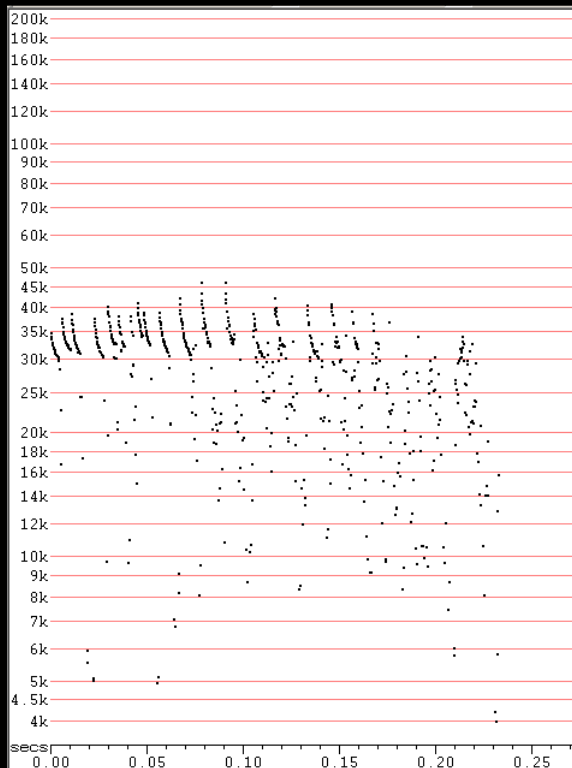
- Acoustic surveys (Anabat II)
- Surveys throughout 2010 – 2011
 - 114 nights (769 detector/nights)
 - Emphasis on April-May, Aug-Oct

- Echoclass v.1.1¹

- High frequency (> 34 kHz)
- Low frequency (≤ 34 kHz)
- Feeding buzzes / night

Methods

Bat Variables

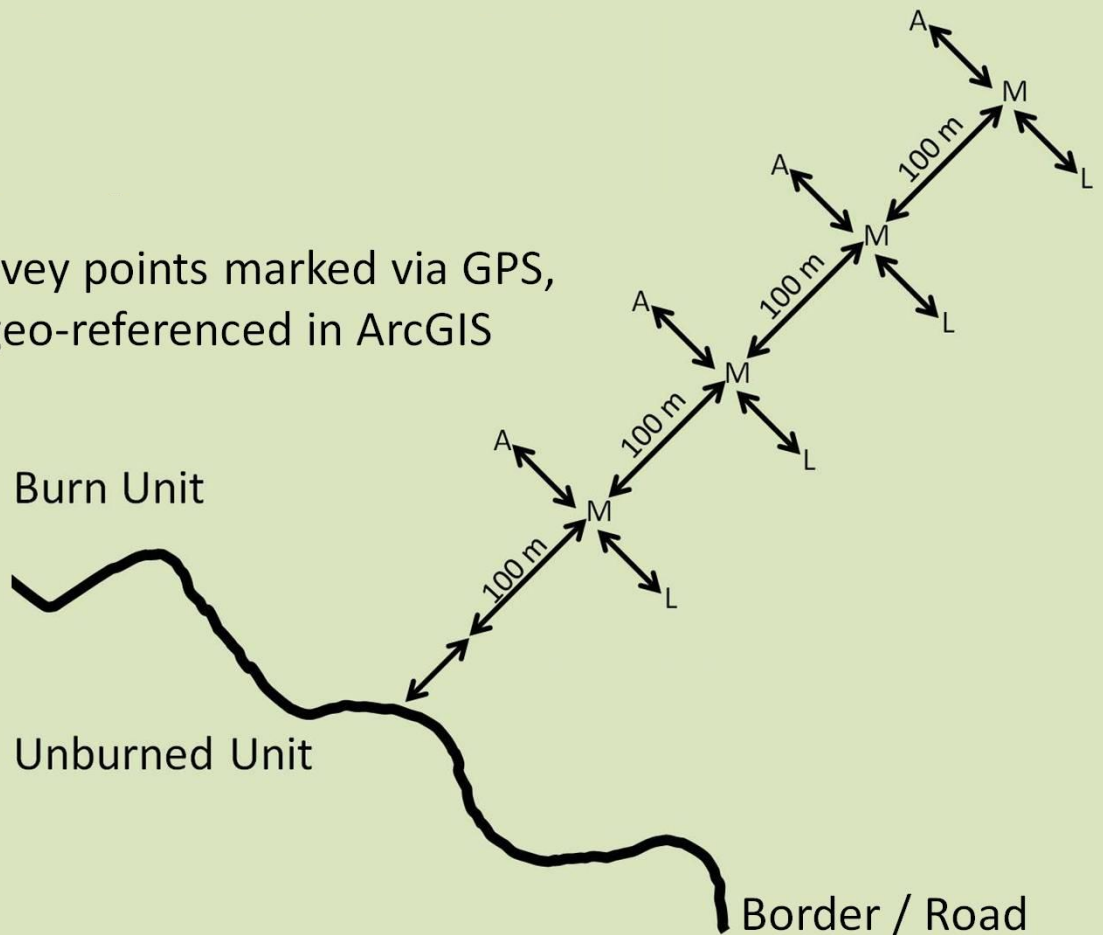


¹USFWS. Accessed 2012. <http://www.fws.gov/midwest/Endangered/mammals/inba/inbasummersurveyguidance.html>

Methods

Mammoth Cave National Park

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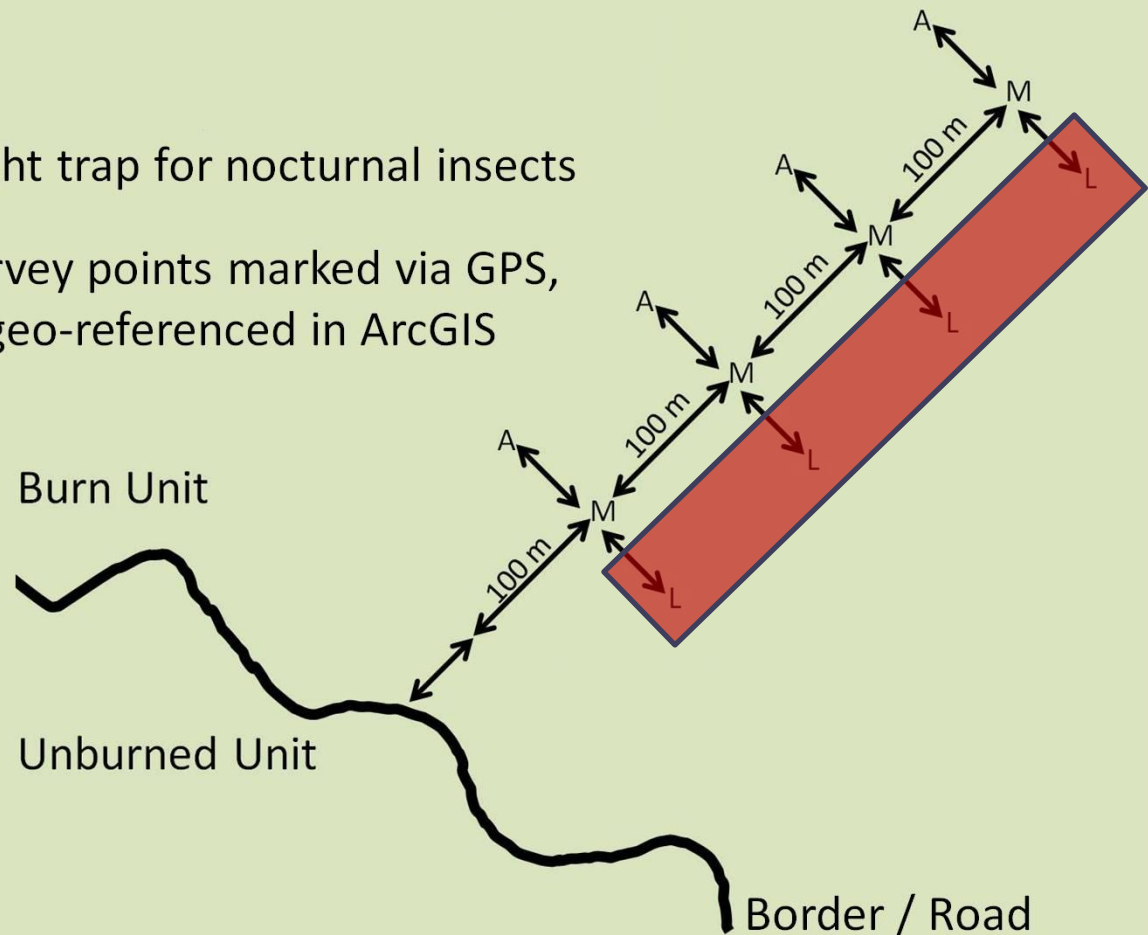


Methods

Mammoth Cave National Park

L = Light trap for nocturnal insects

All survey points marked via GPS,
then geo-referenced in ArcGIS



Methods

Insect Abundance

- Blacklight trap surveys
- Surveys throughout 2010 – 2011
 - 41 nights (205 trap/nights)
 - Emphasis on April-May, Aug-Oct

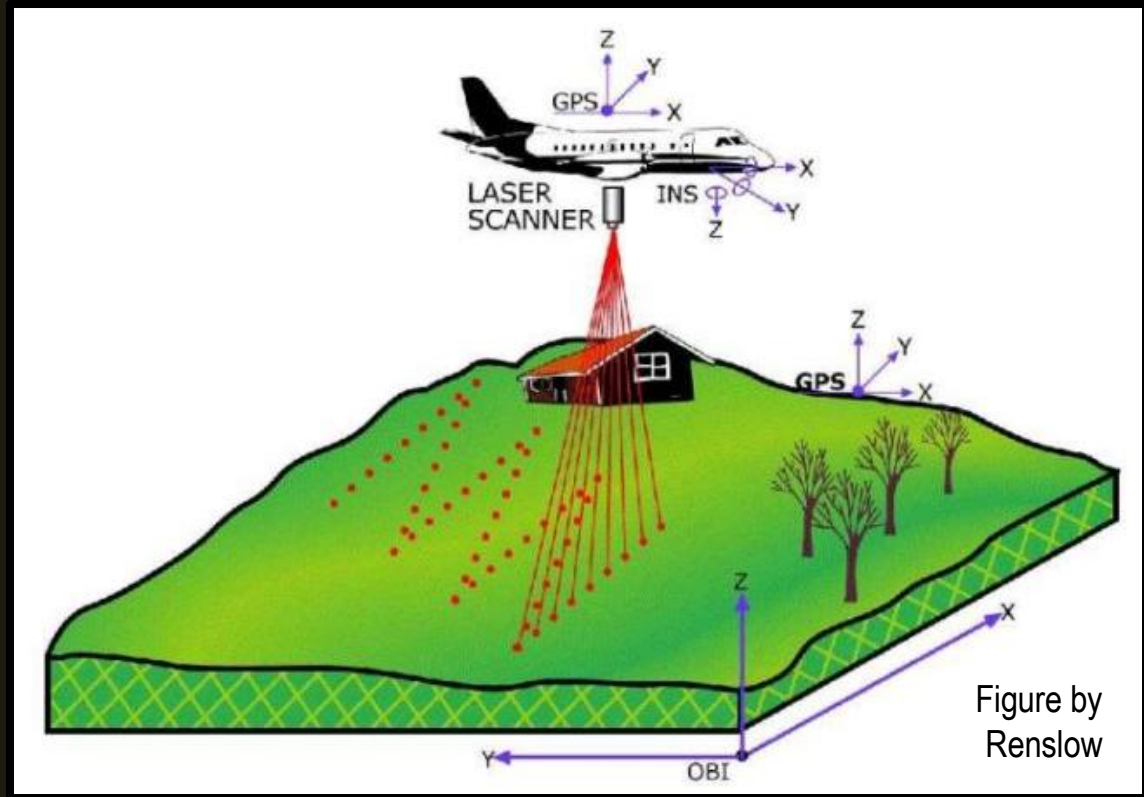
Methods

Insect Variables



Methods

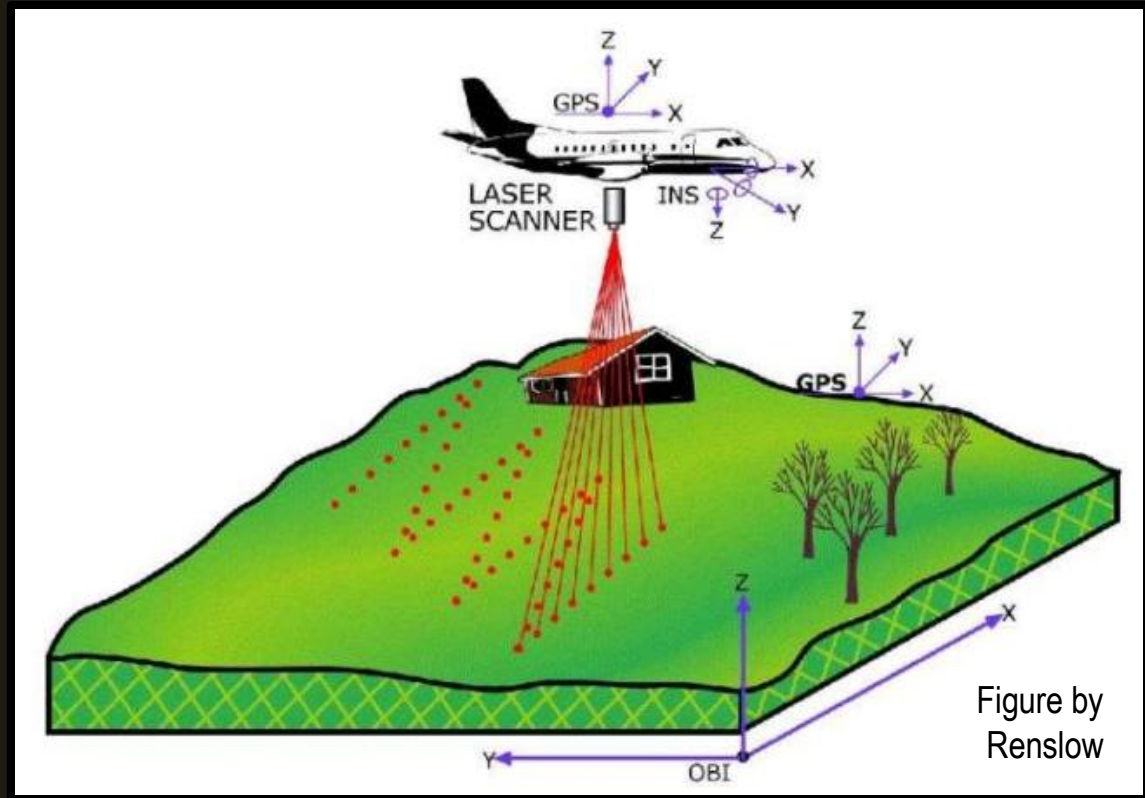
LiDAR Survey



- LiDAR = “Light Detection and Ranging”

Methods

LiDAR Survey

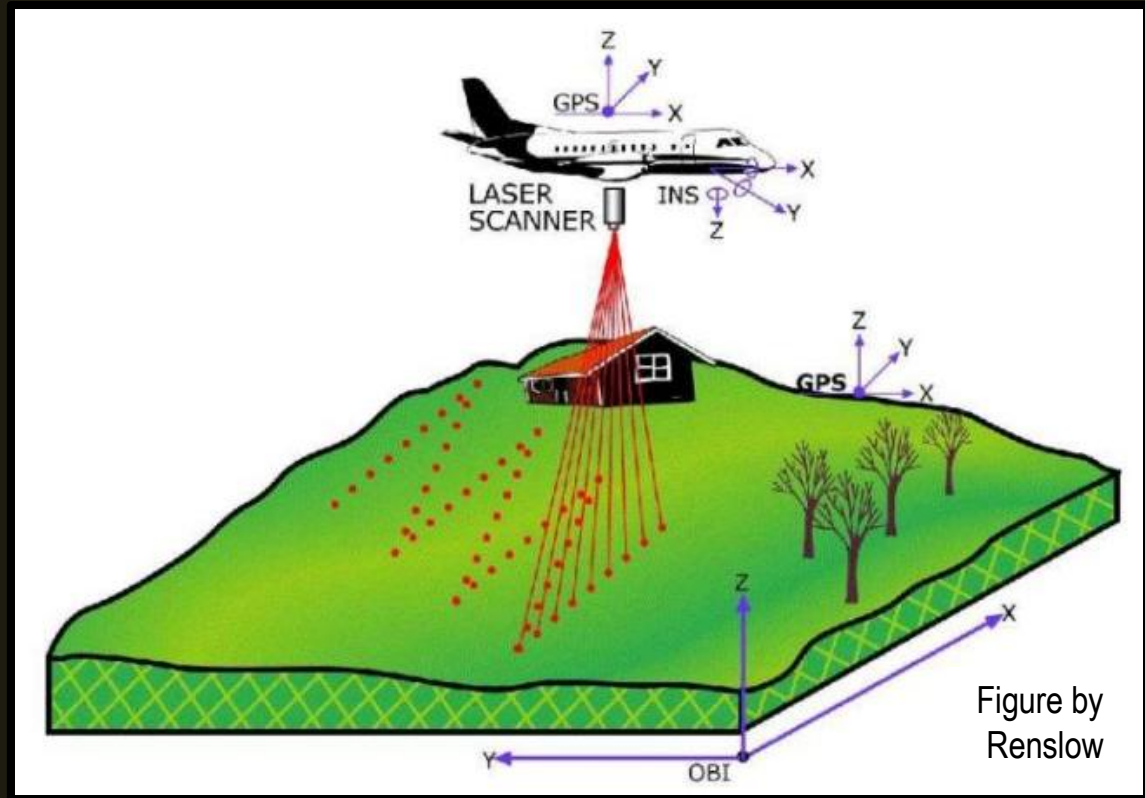


- LiDAR = “Light Detection and Ranging”
- Discrete-return scanning LiDAR¹
 - 900-1,600 nm wavelength
 - > 4 pulses / m²

¹Skowronski et al. 2007. Remote Sensing of Environment 108: 123-129.

Methods

LiDAR Survey

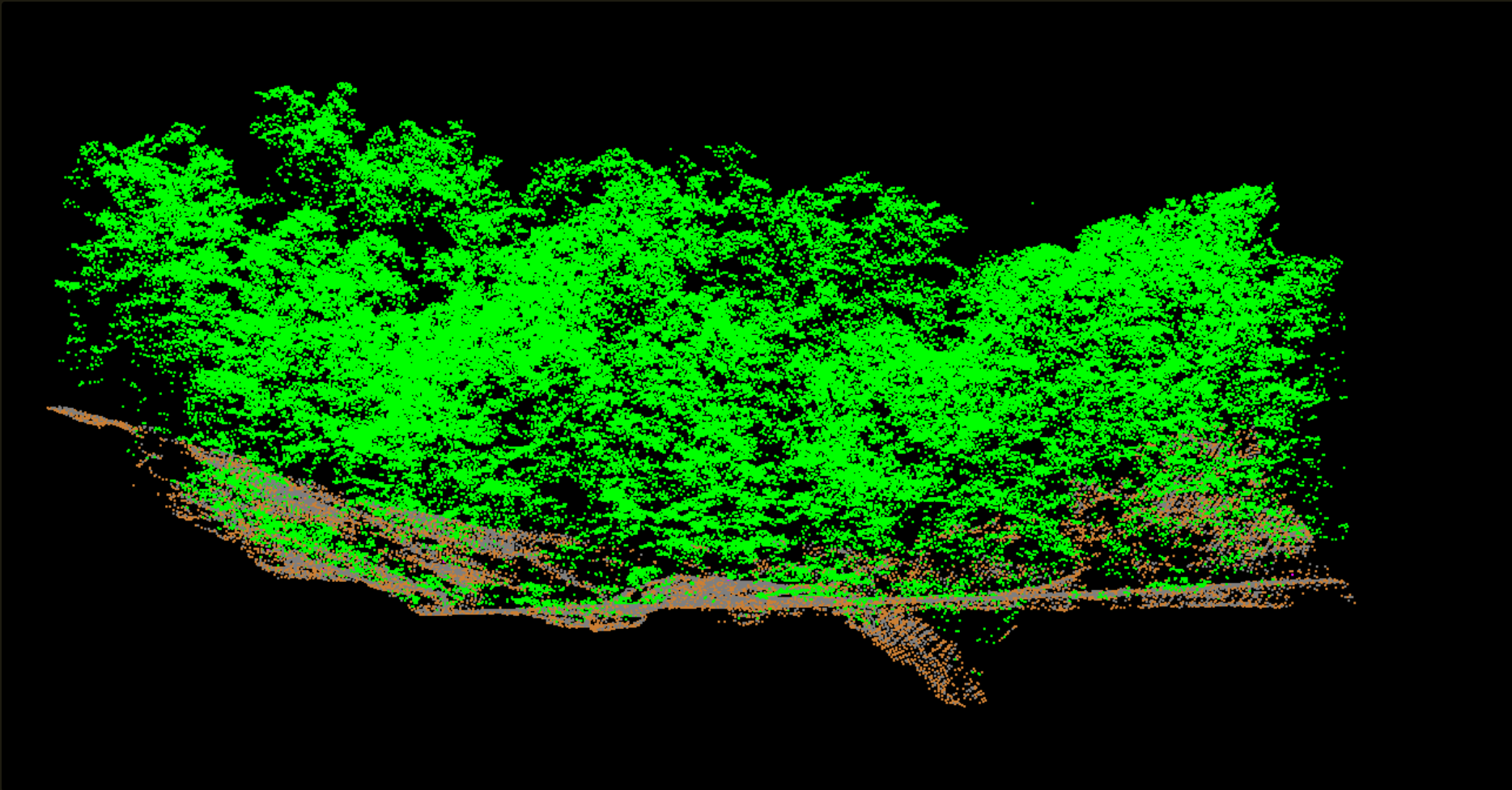


- LiDAR = “Light Detection and Ranging”
- Data collected Oct 2010 (leaf-off) via fixed-wing aircraft

Methods

- What scale is meaningful?

LiDAR Variables



Methods

LiDAR Variables

- Laser returns across over-, mid-, & understory strata¹

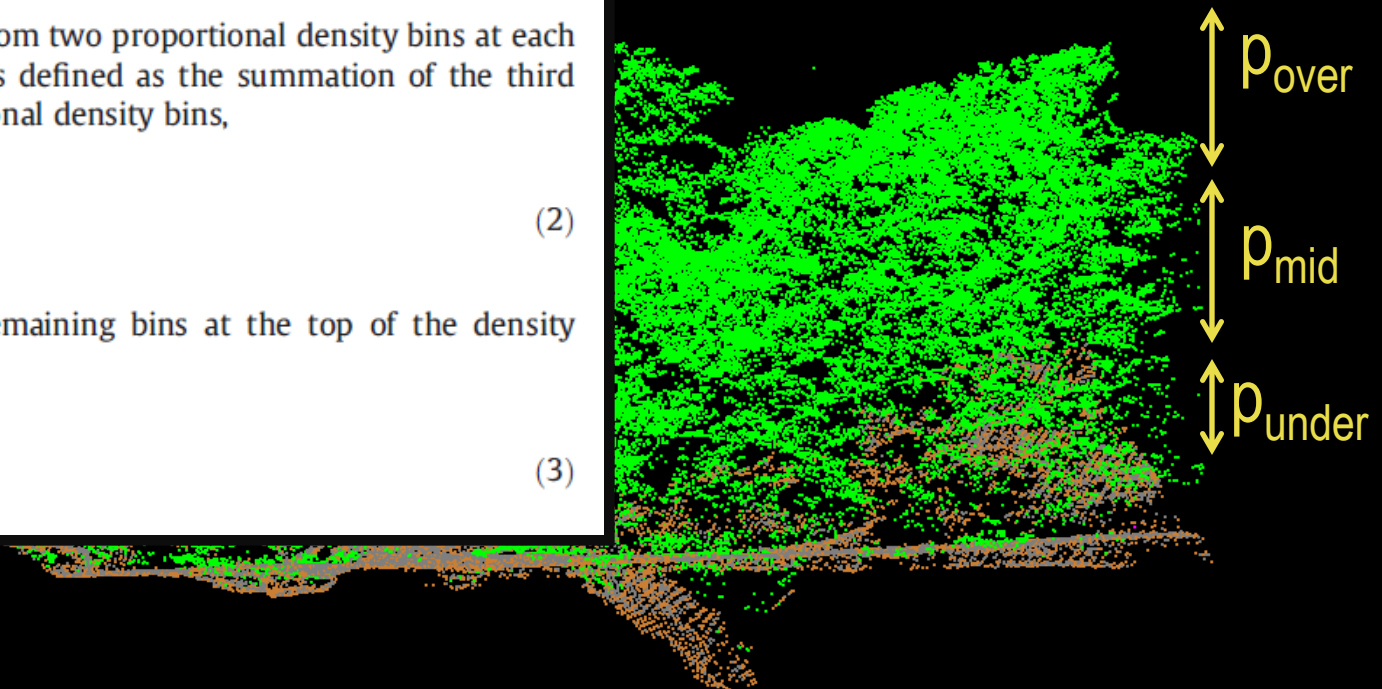
$$p_{under} = \sum_{i=10}^{i=20} p_i, \quad (1)$$

where p_{under} sums the bottom two proportional density bins at each location. The midstory was defined as the summation of the third through the sixth proportional density bins,

$$p_{mid} = \sum_{i=30}^{i=60} p_i, \quad (2)$$

and the canopy by the remaining bins at the top of the density distribution,

$$p_{can} = \sum_{i=70}^{i=100} p_i. \quad (3)$$

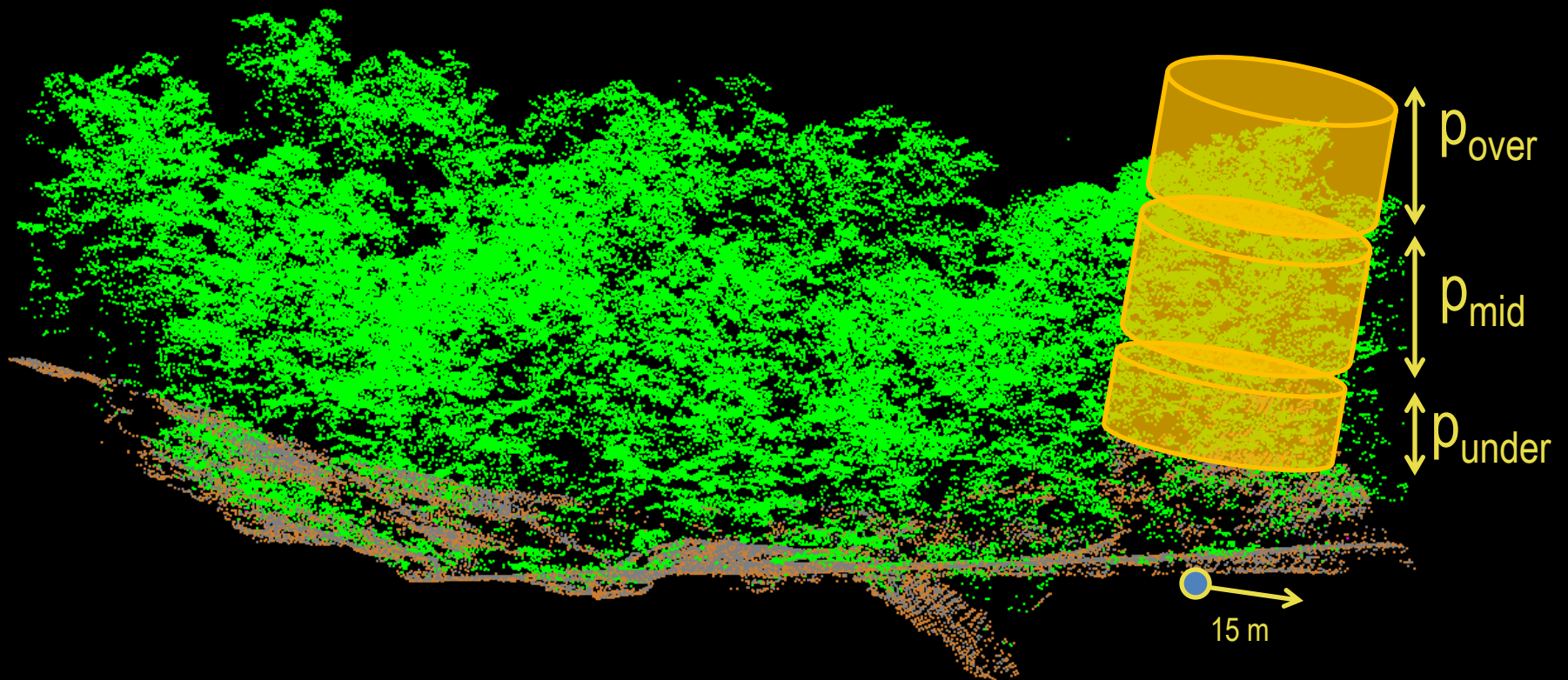


¹Lesak et al. 2011. Remote Sensing of Environment 115: 2823-2835

Methods

LiDAR Variables

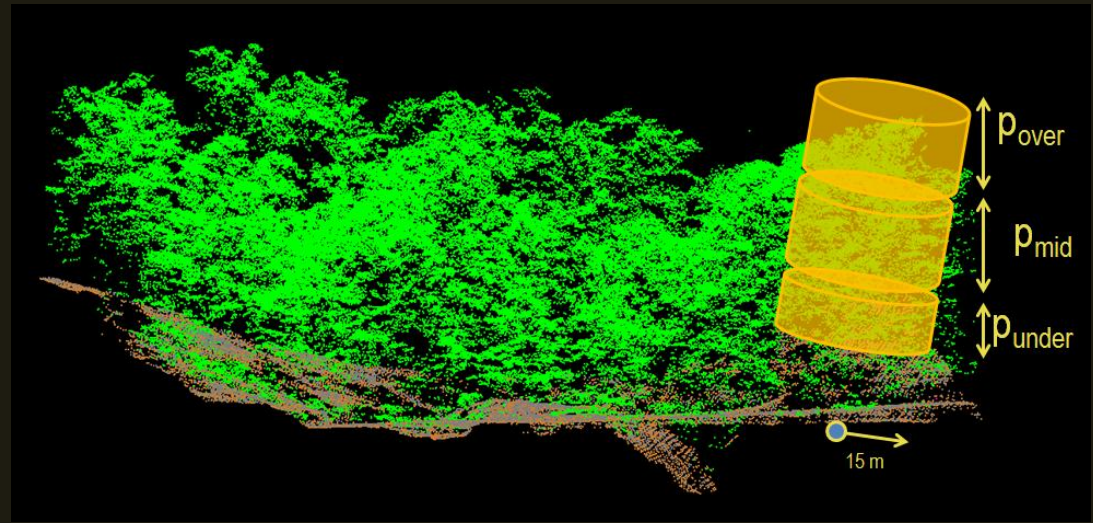
- Laser returns across over-, mid-, & understory strata¹
- 15 m radii around survey points¹



¹Lesak et al. 2011. Remote Sensing of Environment 115: 2823-2835

Methods

LiDAR Variables

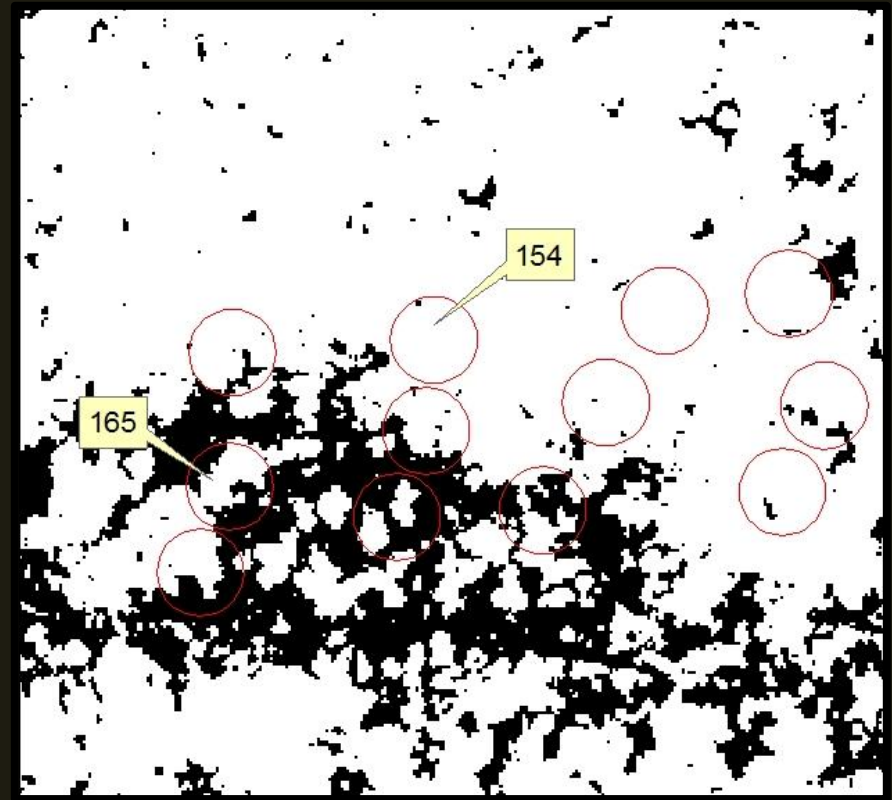


- Strata
 - Over-, mid-, & understory
- Determining canopy shape
 - Mid:Over, Under:Mid, & Under:Over

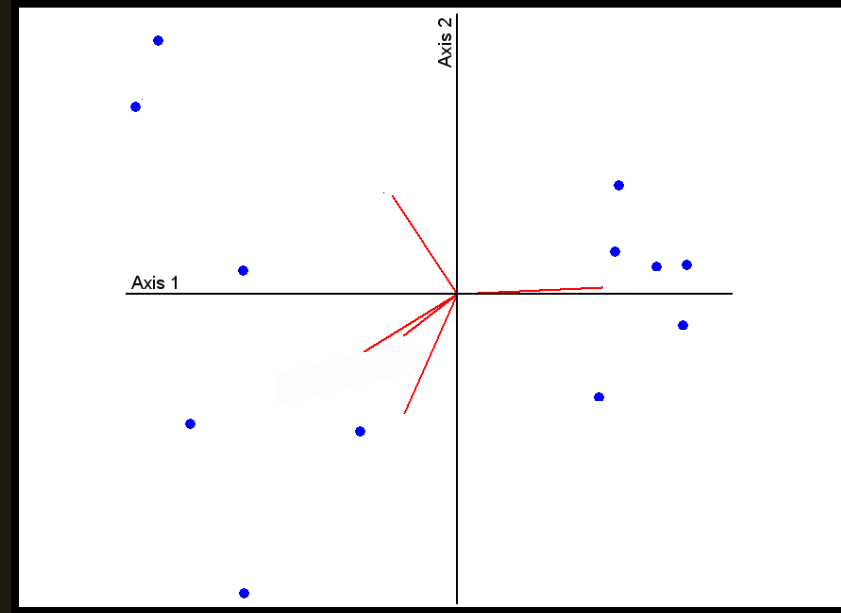
Methods

LiDAR Variables

- Strata
 - Over-, mid-, & understory
- Determining canopy shape
 - Mid:Over, Under:Mid, & Under:Over
- Gap Index
 - Percentage of pixels with no laser returns >3 m height



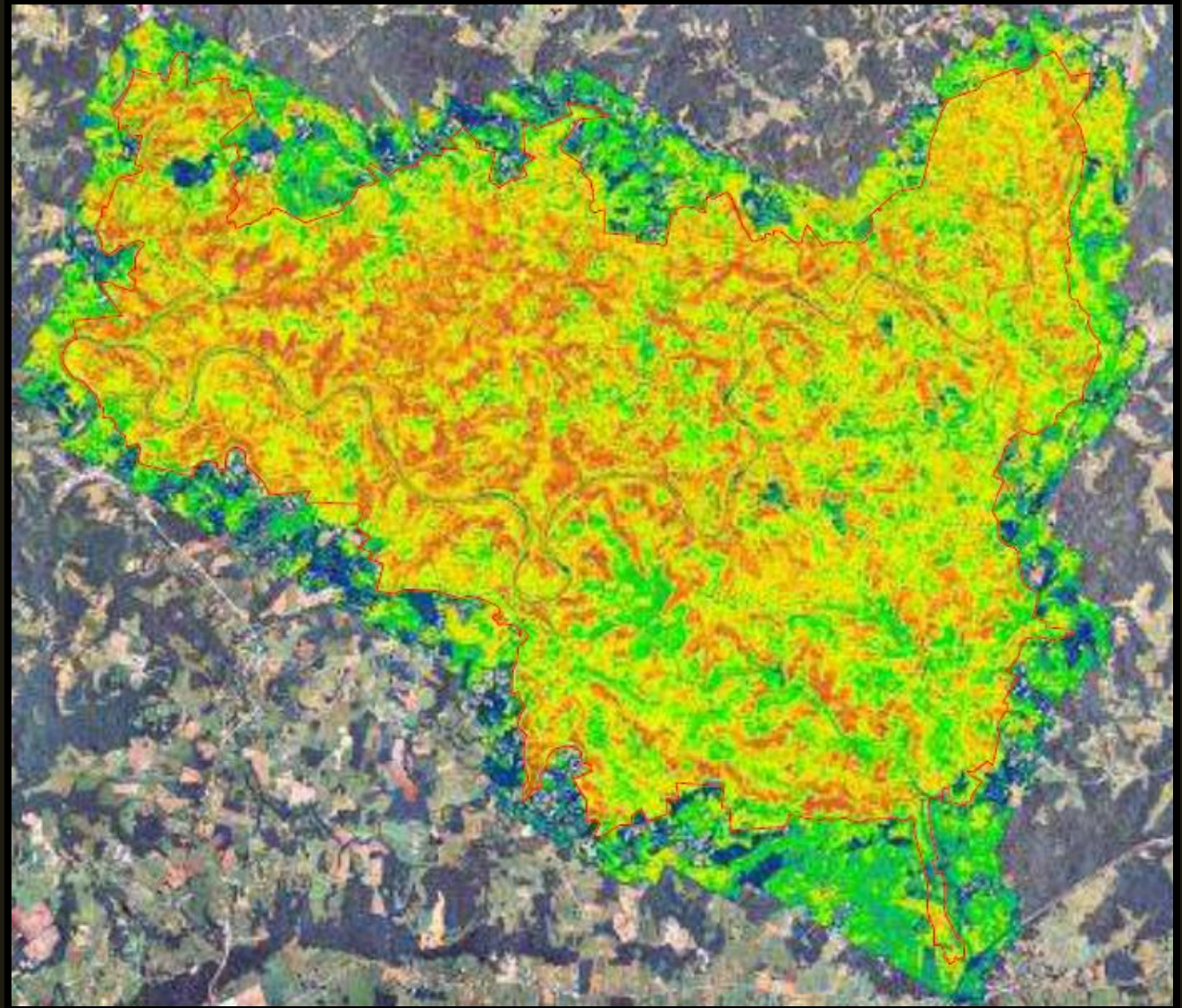
Analysis



- Today's talk... Canonical Correspondence Analysis
 - Standard ordination techniques following ter Braak¹
 - PC-ORD v. 4.25; default settings; 300 iterations
- Future... Predictive models & landscape maps

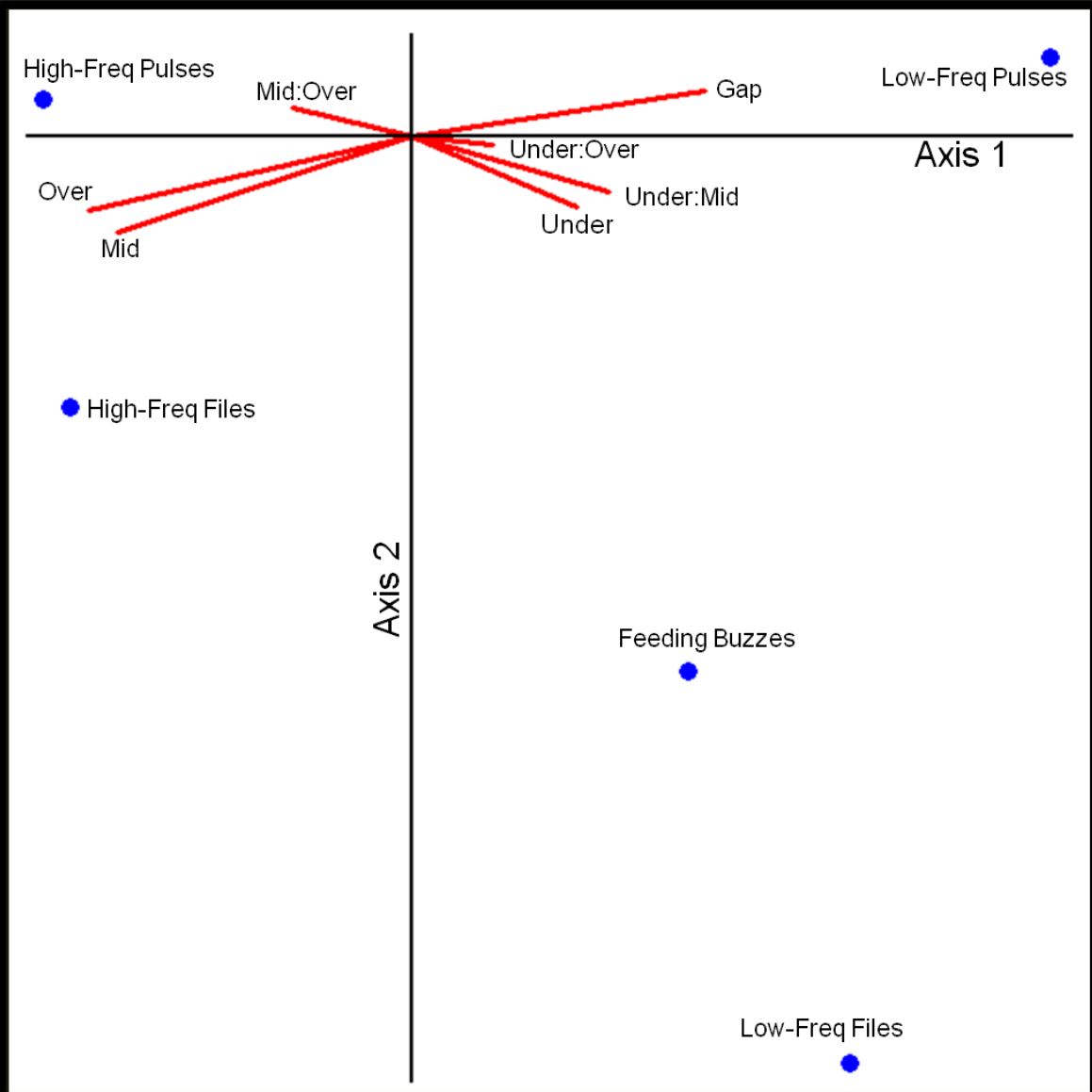
¹McCune & Grace. 2002. Analysis of Ecological Communities. MJM Software Design

Results



Results

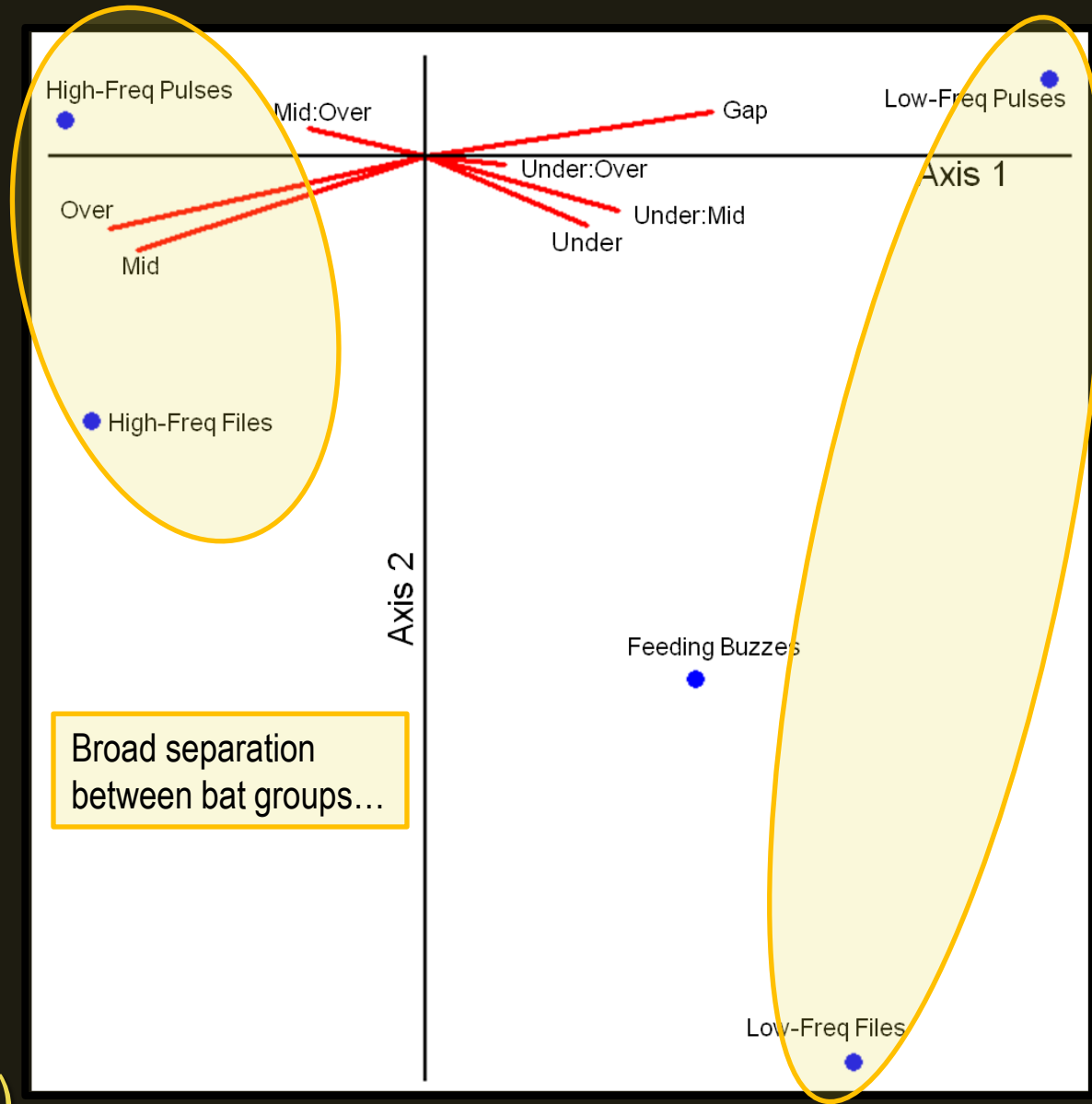
Bats + LiDAR



- 1st & 2nd Axes ($P \leq 0.1$)
- 47% variation explained
- “Inertia” of the data: 0.82

Results

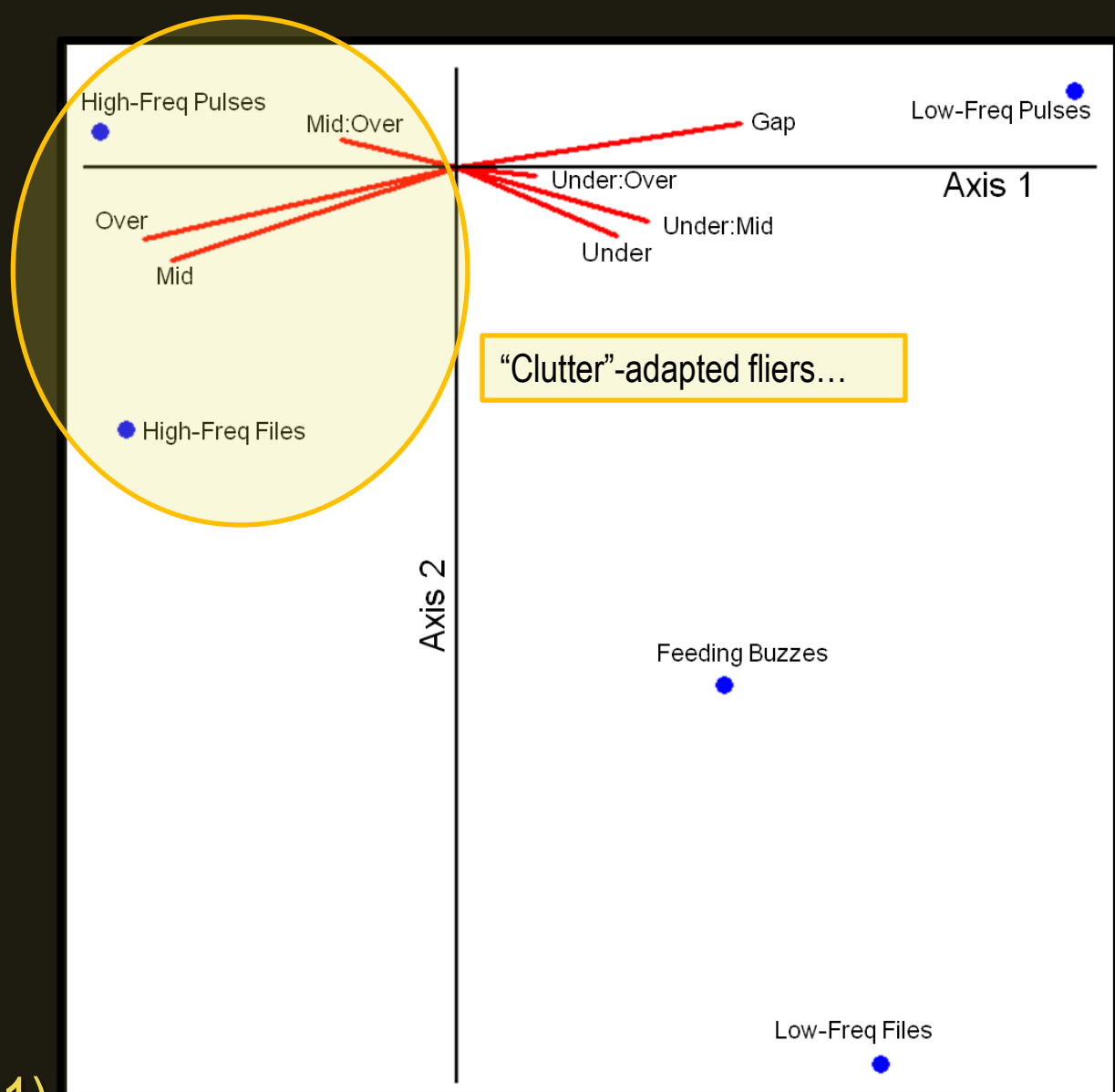
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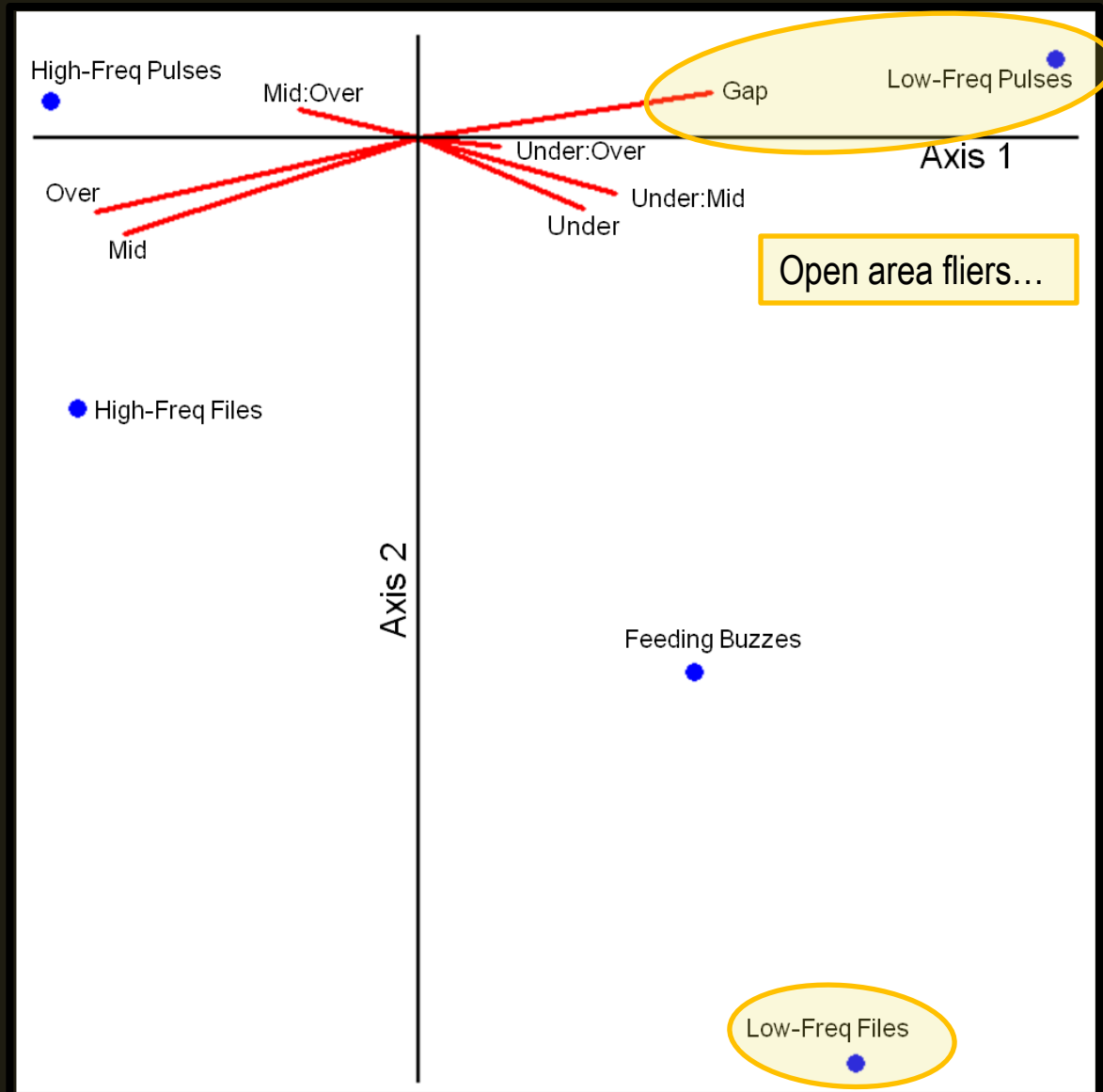
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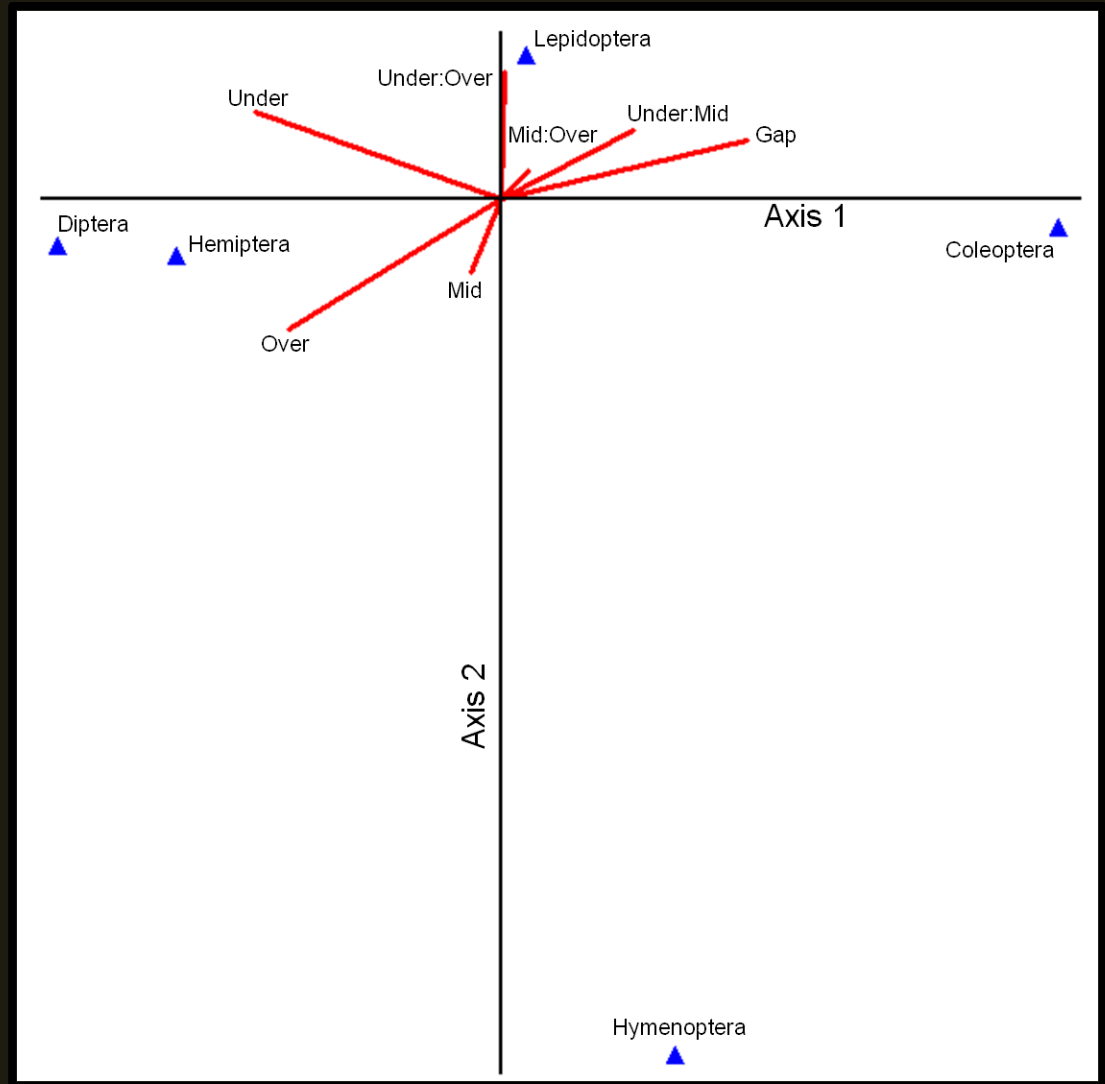
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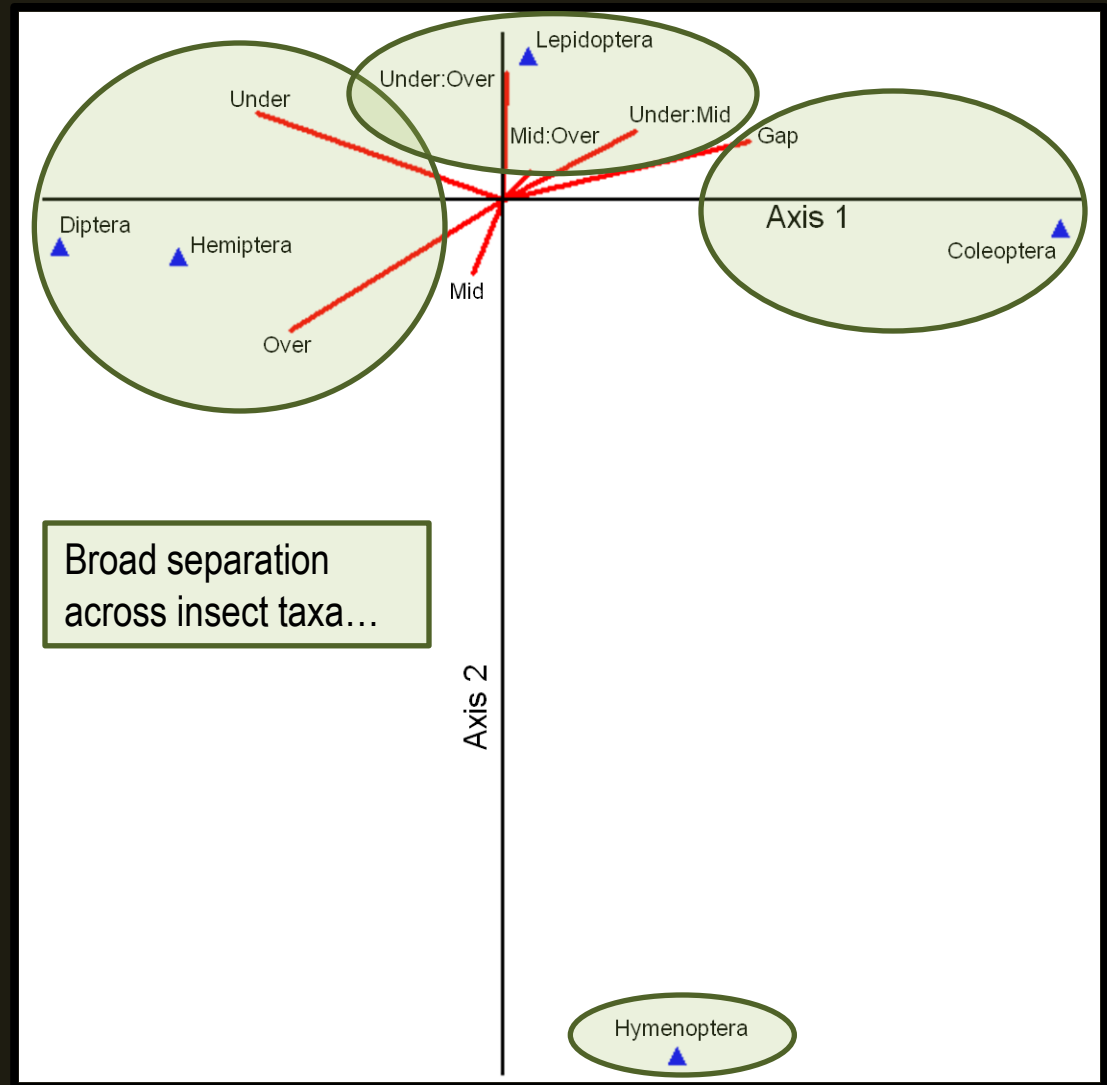
Insects + LiDAR



- 1st Axis ($P \leq 0.05$)
- 11% variation explained
- “Inertia” of the data: 1.03

Results

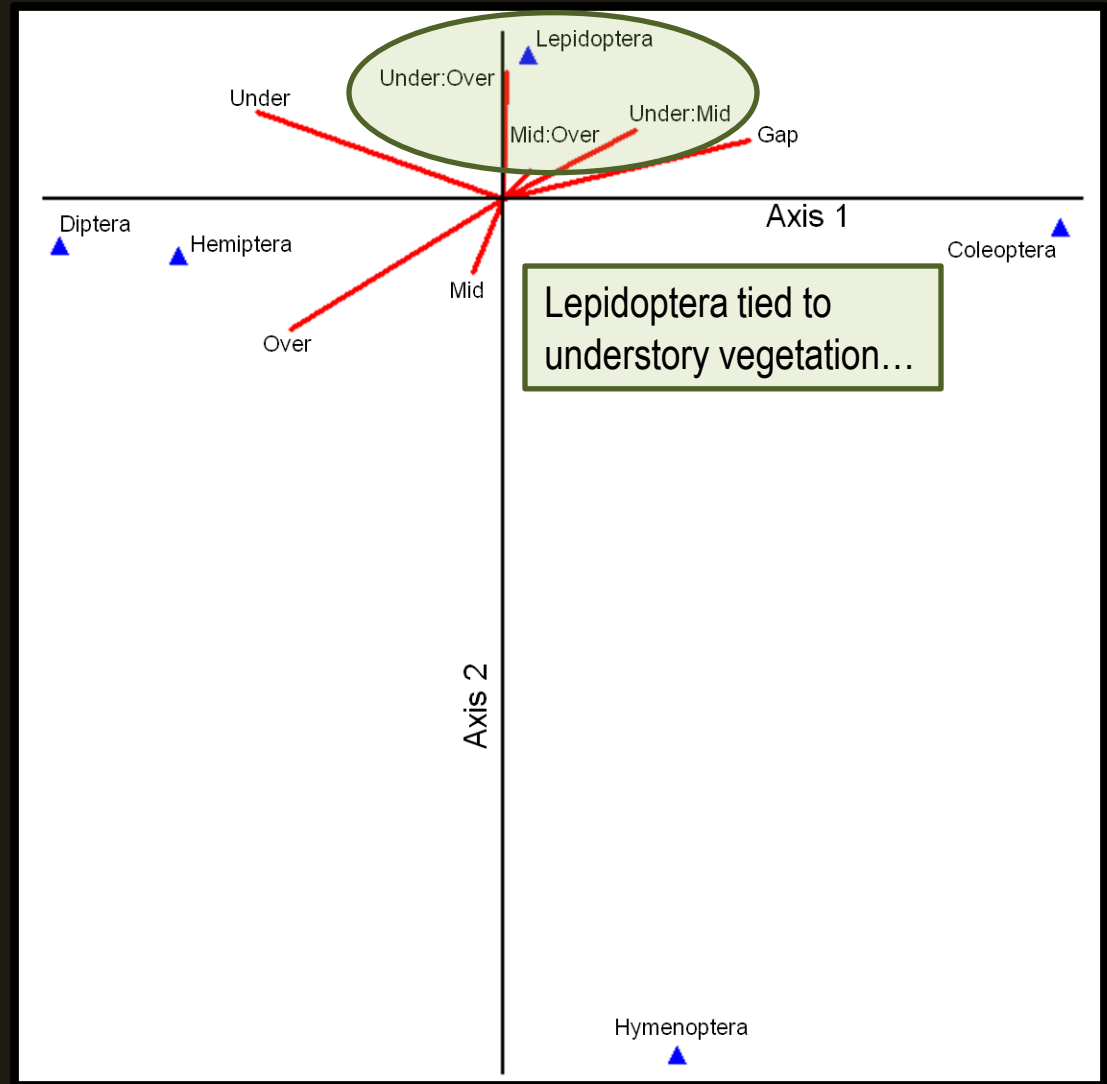
Insects + LiDAR



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- “Inertia” of the data: 1.03

Results

Insects + LiDAR



- 1st Axis ($P \leq 0.05$)
- 11% variation explained
- “Inertia” of the data: 1.03

Discussion & Implications

- High frequency echolocators positively associated with cluttered forest canopies¹; not so for low frequency echolocators²



¹Swartz et al. 2003. Pp. 257-300 in: Bat Ecology.

²Lacki et al. 2007. Pp. 83–128 in: Bats in Forests: Conservation and Management

³Dodd et al. 2012. Forest Ecology and Management 267: 262-270.

Discussion & Implications

- High frequency echolocators positively associated with cluttered forest canopies¹; not so for low frequency echolocators²
- Insect groups variable in their relationships to canopy structure³



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²Lacki et al. 2007. Pp. 83–128 in: Bats in Forests: Conservation and Management

³Dodd et al. 2012. Forest Ecology and Management 267: 262-270.

Thanks!

- Funding
 - Joint Fire Science Program
- NPS Personnel
 - Dr. Rick Toomey
 - Steve Thomas
 - Shannon Trimboli
- Tech Support!
 - Tracy Culbertson
 - Klint Rose
 - Jennifer Winters

